

GIS in Community Health Assessment and Improvement

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Abstract

The Clackamas County Geographic Information Systems Demonstration Project is designed to engage diverse communities in partnerships to make improvements in community well-being. An interdisciplinary team has developed a software system, the Community Health Mapping Engine (CHiME), that allows the easy incorporation of multiple datasets related to community well-being. Through a Healthy Communities partnership process, multiple agencies, both private and governmental, are beginning to share data, allowing the data to be incorporated into the CHiME. The CHiME uses readily available data obtained from vital statistics bureaus, the US Census, private sources (such as hospital discharge data), and county government collected data such as reported crime. The demonstration geographically references these datasets, allowing analysis in a geospatial format at the sub-county, community level. Interested community members and agencies can apply a user-friendly, ultimately Web-based interactive mapping function to assess a variety of health and social demographic factors and benchmarks related to community health and well-being. The demonstration is flexible and modular. As additional public and private datasets become available, the "Data Wizard" can easily incorporate them into the CHiME for use by community members. We are incorporating safeguards to protect confidentiality during small area analysis. The demonstration performs statistical analysis, including confidence intervals, allowing community members to compare their community indices with county, state, and national rates and benchmarks, and follow trends over time. Although current datasets and functionality are limited to Clackamas County, we designed the application to allow expansion to accommodate other regions and geographic scales (counties, states, and nations).

Keywords: community health planning, community well-being, health status indicators, public health administration, data collection

Introduction

The goal of the Clackamas County Geographic Information Systems Project is to increase the capacity of Clackamas County staff and Clackamas County community members by making data analysis and data presentation more accessible, localized, and community-based. By accessible, we mean that community members and interested agencies should be able to obtain relevant information about the health status of their communities at a variety of sites, including local libraries and home computers. By localized, we mean that community-level health data should be available for analysis at the neighborhood/community level. By community-based, we mean that local

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communities should be able to determine for themselves what information about their community is relevant, and that local and state governments should be a resource for these communities in providing for their data needs.

Although local and state governments routinely collect data related to community health status, the data are rarely used by local health consumers and planners for several reasons. First, the data are not timely. For example, up to two years may elapse before vital statistics data are released in hard copy form. Once the data are released, the hard copy report contains limited county level analysis and is not amenable to further data manipulation. Local planners are left to ask the responsible state agency to make specific data runs, requiring additional time and staff support. Second, a variety of health-related data is collected and maintained in different formats by many different agencies at the local, state, and federal levels and is not available in one convenient location accessible to community health planners. Third, health data are analyzed and reported only at the county, state, and national levels. Larger counties often contain many diverse and sizable communities whose borders do not necessarily coincide with other political boundaries and whose characteristics are not captured accurately by summaries based on these boundaries. Consequently, data analyzed and reported at the county level or higher are frequently not useful for many local communities in conducting health assessment and planning. Such data provide little opportunity for local public health professionals to seek dialogue and strengthen relationships with local communities.

The Clackamas County Department of Human Services Geographic Information Systems (GIS) Project is designed to address these issues. Our objectives are to improve access to data by local health consumers and planners and thereby engage our diverse communities in a partnership with us to improve community health. An interdisciplinary team has developed a prototype software application, the Community Health Mapping Engine (CHiME), that allows the easy incorporation of multiple datasets online in a timely manner. Through the Healthy Communities partnership process, multiple agencies, both private and governmental, are beginning to share data, allowing the data to be incorporated into the system. We are encouraging these partners to share datasets that include addresses. These datasets will be geographically referenced to allow analysis in a geospatial format at the local, sub-county community level. Census data (and inter-census data) will serve as the denominator for rates. The Clackamas County CHiME is intended to serve as both an enterprise GIS model and a tool to facilitate community health planning. As an enterprise GIS, the CHiME will serve as a centralized assessment tool for use by multiple county agencies and partners. The future Web-based version of the CHiME, with its help features, will be publicly available to community-based groups and consumers interested in performing community health assessments.

The CHiME will provide Clackamas County communities with a tool to help themselves in at least two ways. It will enable them to assess a variety of factors related to community well-being, and it will allow them to evaluate any actions they take in improving their health status.

Methods

We designed the system for two user skill levels: community members without formal

epidemiologic skills, and advanced epidemiologic investigators. As the prototype is further developed, an initial screen will contain text that describes the project, lists data and data sources, and provides instructions on how to use the system. An epidemiology tutorial will be built into the system for those unfamiliar with epidemiologic concepts. Besides providing instructions on how to use the system, screens will provide easily understood explanations of concepts such as incidence rates, prevalence, confidence intervals, and the need for age adjustment when evaluating mortality rates. Pop-up help screens will contain messages discussing the concept of ecologic fallacy and the need to avoid drawing conclusions when cause-and-effect relationships have not been previously established (1). Help icons and screens will be available at all times. Links to appropriate county health officials will be included, allowing users to ask questions and obtain consultation. Links to other online information sources also will be provided.

Within the current prototype application, users can analyze data at the sub-county, community level as well as at state and county levels, and can present their findings in table, chart, and polygon/map format. Census data (and estimated inter-census data) provide information about demographic characteristics and population counts. For the current prototype application, we purchased inter-census data from a private provider, Equifax National Decision Systems (ENDS) (Atlanta, GA). ENDS provides current-year estimates of demographic and population data in a variety of formats, including ArcView, and has a history of providing such data for commercial use.

The CHiME enables users to compare their community measures with countywide data, statewide data, Oregon benchmarks, and (eventually) national data. Users can compare measures for each geographical area over time and automatically calculate confidence intervals. When rates for a single year are unstable due to small numbers, users can analyze data aggregated over several years. The CHiME can display table and chart data whenever users click on a state, county, or community. The information displayed for each geographic level of analysis includes absolute numbers of events, rates, means, medians, and confidence intervals. Users can zoom in or out among the levels. Users can evaluate two variables simultaneously, so they can visualize spatial patterns and relationships. For example, users can evaluate relationships between teen birth rates and risk factors such as poverty.

A "Data Wizard" allows the project administrators to easily incorporate additional datasets into the system. This Wizard facilitates the process of geocoding and adding new data to the CHiME. Varieties of common data formats are supported. Each dataset must include an address field for purposes of geocoding. Table 1 lists types of data currently included in the CHiME. Several of these datasets currently only allow analysis at the county level or above. Datasets allowing analysis at the sub-county level will be added as address fields are completed. We envision that all health-related data eventually will include an accurate address field to enable analysis at the community level. Examples of data of special interest include mortality (so the CHiME could calculate years of potential life lost [YPLL] and age-adjusted mortality rates at the community level); immunization rates for children aged two years; cancer registry data; high school dropouts; commuting time; and, domestic abuse (including elder, child, and spouse). In addition, we plan to include data such as hospital discharge diagnoses through working partnerships with health care systems and health care providers.

Once the application is Web-based, we will ensure confidentiality in two ways.

Table 1 Data Included in the Clackamas County CHiME, 1998

Variables	County Level of Analysis	Community Level of Analysis	Years	Data Sources
Age, gender, race	X	X	Single years: 1990 to 1996	Equifax National Decision Systems
Personal income	X	X	Single years: 1990 to 1996	Equifax National Decision Systems
Births (including repeat births)	X	X	Single years: 1990 to 1996 Aggregate: 1991 to 1995	Oregon Health Division, Vital Statistics
Abortions	X		Single years: 1990 to 1996 Aggregate: 1991 to 1995	Oregon Health Division, Vital Statistics
Pregnancies	X		Single years: 1990 to 1996 Aggregate: 1991 to 1995	Oregon Health Division, Vital Statistics
Deaths	X		Single years: 1990 to 1996 Aggregate: 1991 to 1995	Oregon Health Division, Vital Statistics
Suicides	X	X	Single years: 1990 to 1996 Aggregate: 1991 to 1995	Oregon Health Division, Vital Statistics
Arrests	X	X	Single years: 1990 to 1996 Aggregate: 1991 to 1995	Clackamas County Sheriff's Department
Reported crimes	X	X	Single years: 1990 to 1996 Aggregate: 1991 to 1995	Clackamas County Sheriff's Department

First, agencies sharing data will use the Data Wizard to geocode individual records and then aggregate the records into defined geographic communities. Agencies will thus remove all individual identifiers before sharing the data with the CHiME. Not only does the Wizard help assure confidentiality, its geocoding and aggregating properties have already encouraged formerly reluctant agencies such as hospitals to share their data with us. Once the data are in the CHiME, we will further ensure confidentiality by restricting analysis, reporting, and depiction of very small numbers, especially when multiple stratification is performed.

For compatibility with population data sources (used for the denominators), we have defined communities as census block groups aggregated to approximate high school attendance areas. We chose not to use zip codes because they cross community and city boundaries and it is difficult to obtain denominator data for them. Following community input, the Data Wizard could aggregate block group data to create maps for alternative target areas such as legislative districts, elementary school attendance areas, or other user-defined small areas. We conducted several focus groups, including those with the elderly, teens, and minority populations, who concurred with our initial decision to use high school attendance areas as geographic community definitions.

In Figures 1 through 12, the CHiME has been used to generate sample maps that show teen male arrest rates, teen birth rates, and adequacy of prenatal care by high school attendance areas. Juvenile (teen) arrests, teen pregnancy rate, and adequacy of prenatal care are three of Oregon's benchmarks, measurable indicators for which data are reliably, regularly, and economically available. Oregon currently has 92 benchmarks, reduced this past year from 259. Benchmarks are developed through a public

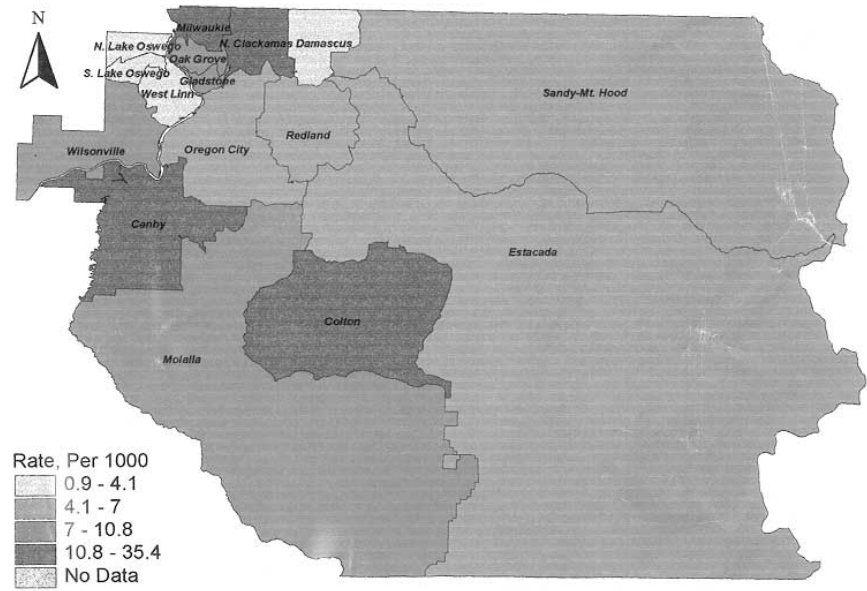


Figure 1 1996 community-level teen birth rates by quartile (CHiME).

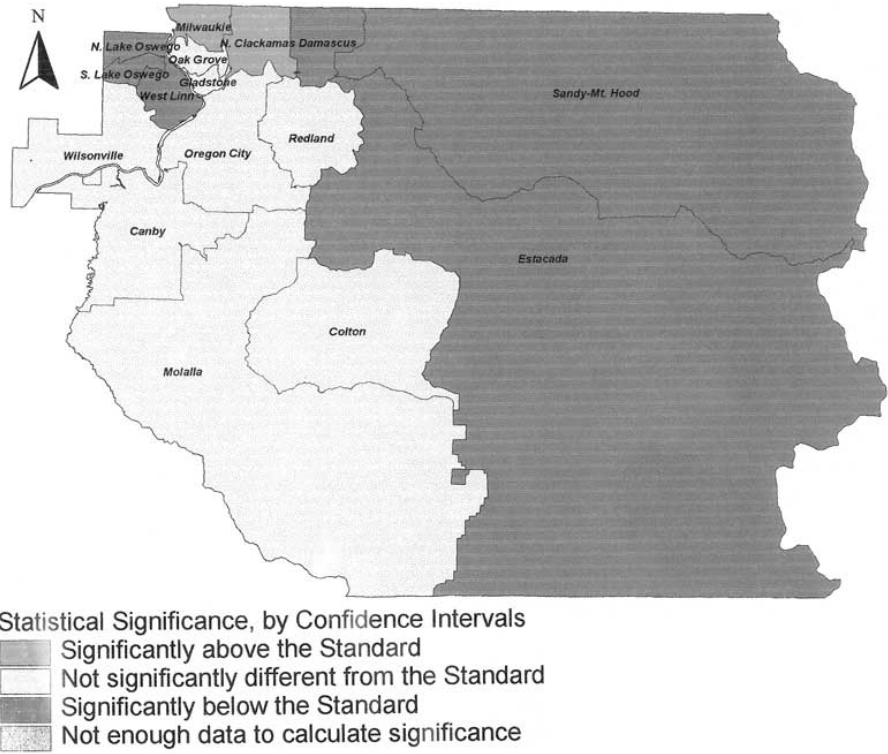


Figure 2 1996 community-level teen birth rates compared with the state rate (CHiME).

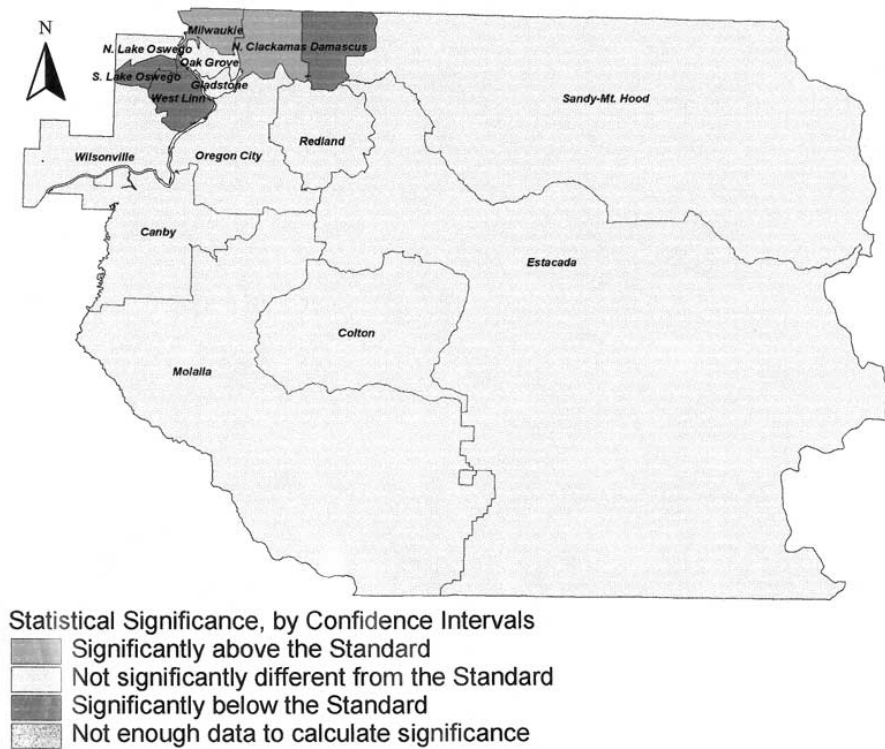


Figure 3 1996 community-level teen birth rates compared with the county rate (CHiME).

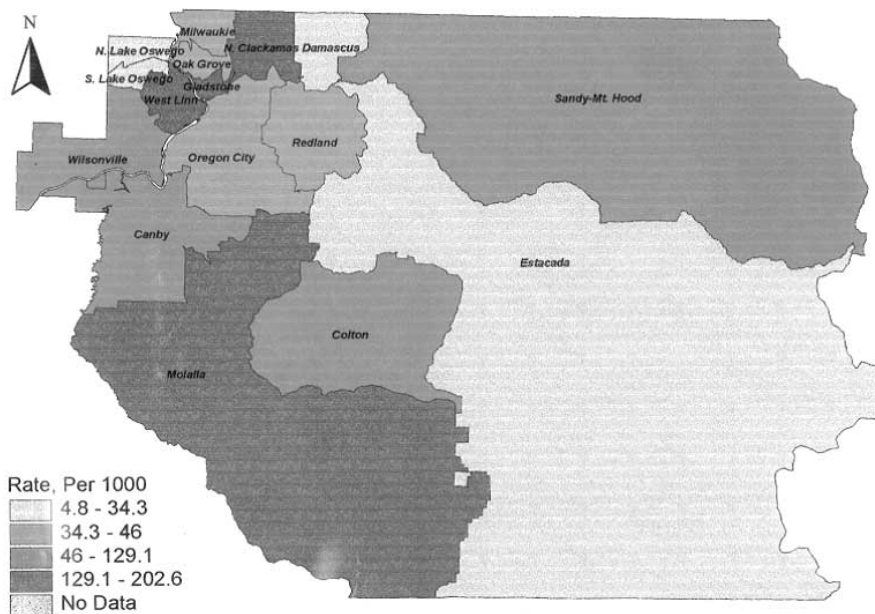


Figure 4 1995 community-level teen male arrest rates by residence by quartile (CHiME).

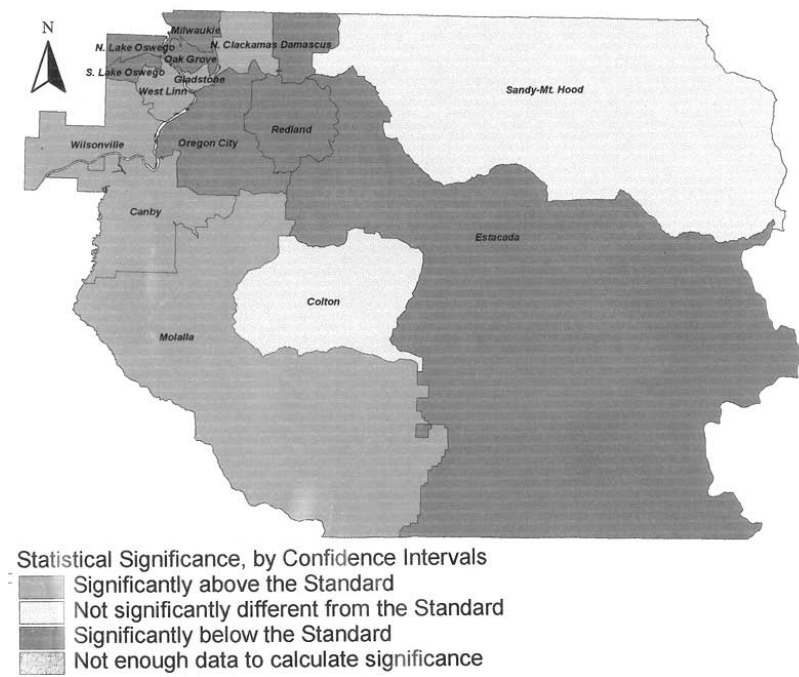


Figure 5 1995 community-level teen male arrest rates compared with the county rate (CHiME).

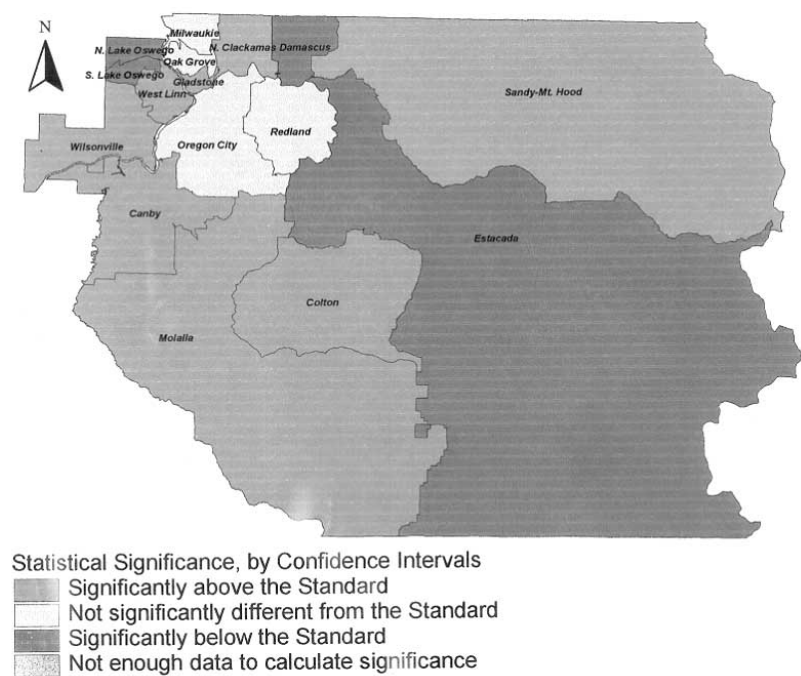


Figure 6 1995 community-level teen male arrest rates compared with the Year 2000 Oregon state juvenile arrest rate benchmark (CHiME).

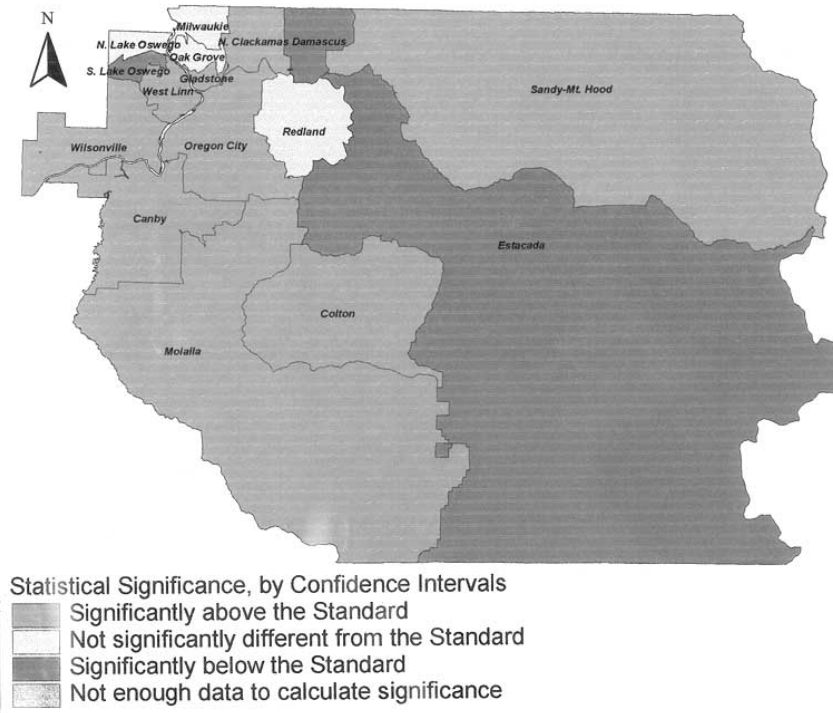


Figure 7 1995 community-level teen male arrest rates compared with the Year 2010 Oregon state juvenile arrest rate benchmark (CHIME).

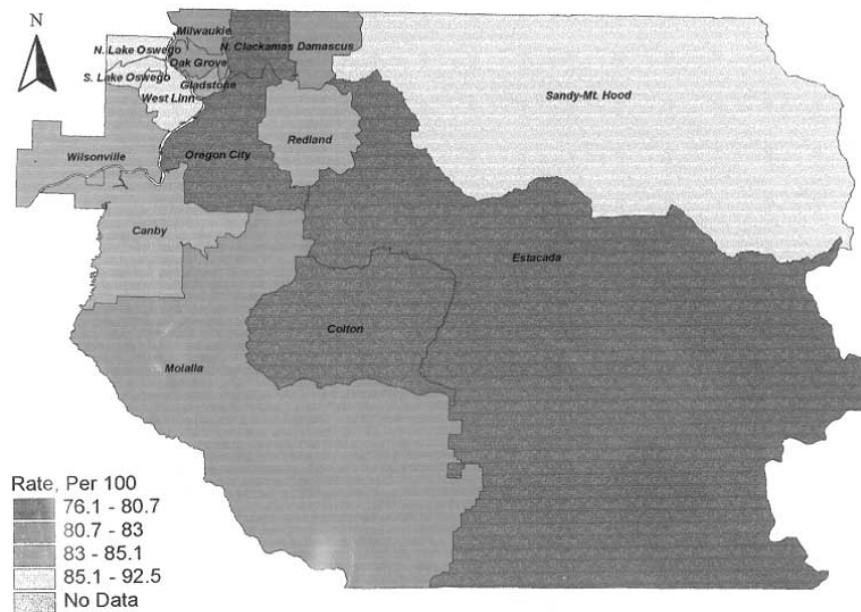


Figure 8 1996 community-level percentage first trimester care by quartile (CHIME).

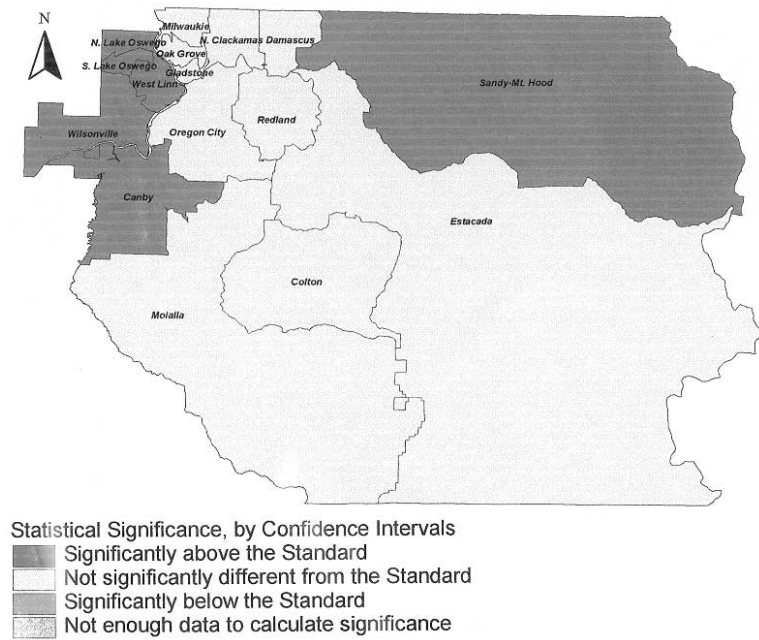


Figure 9 1996 community-level percentage first trimester care compared with state percentage (CHiME).

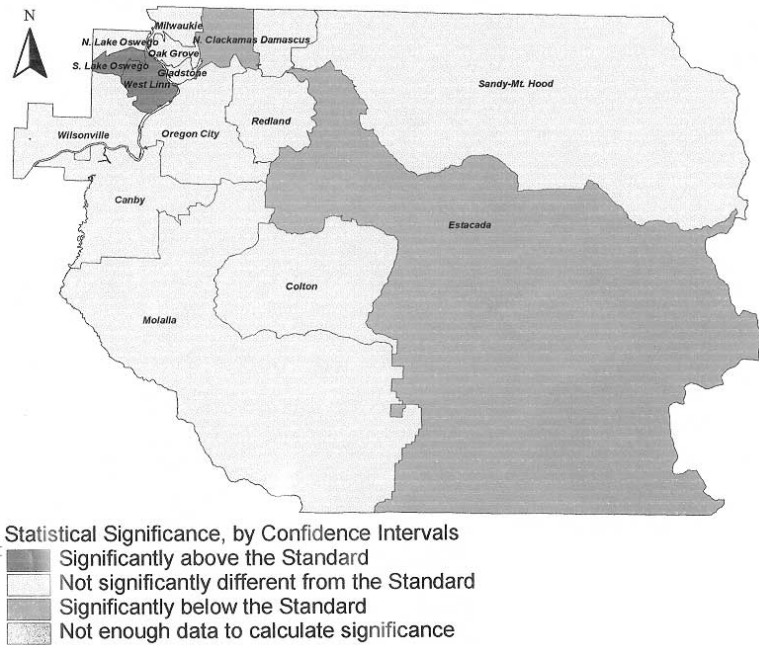


Figure 10 1996 community-level percentage first trimester care compared with county percentage (CHiME).

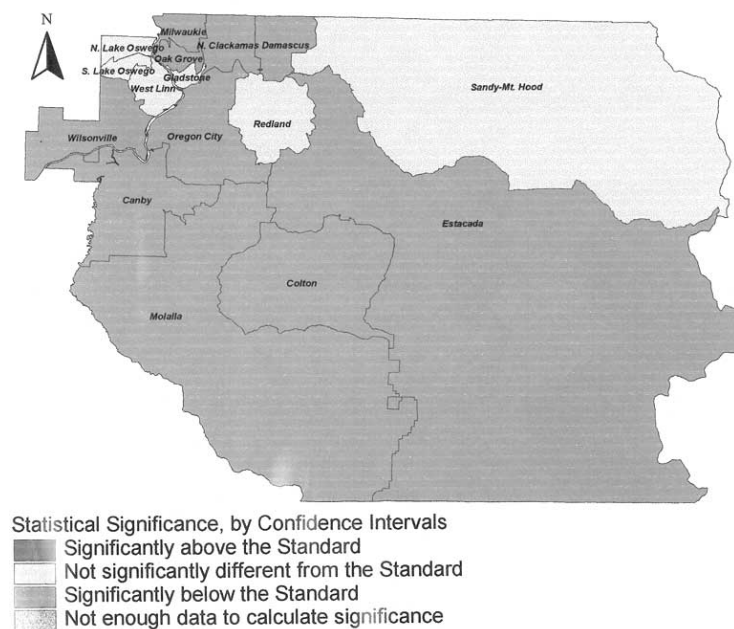


Figure 11 1996 community-level percentage first trimester care compared with the Year 2000 Oregon first trimester care benchmark (CHiME).

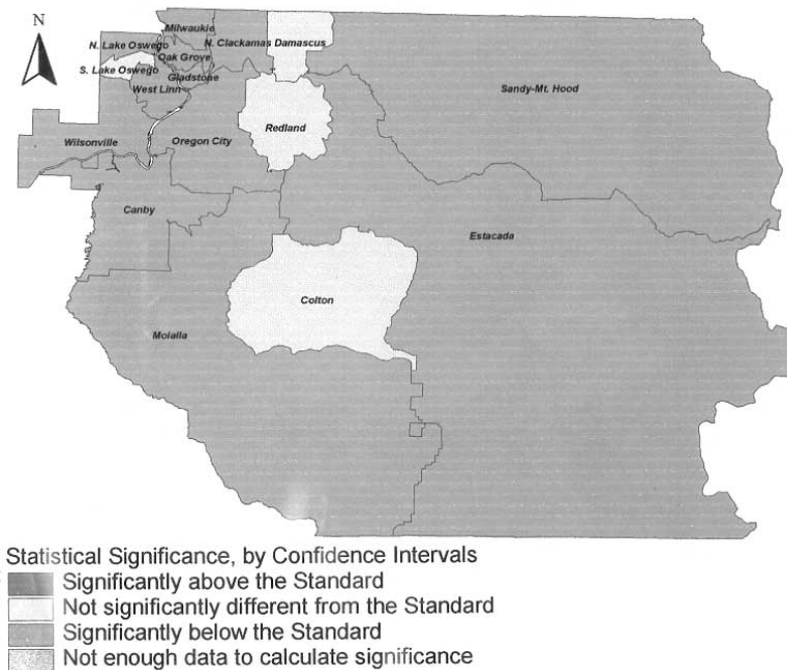


Figure 12 1992-1996 aggregate community-level percentage first trimester care for Hispanic women compared with the Year 2000 Oregon first trimester care benchmark (CHiME).

process by the Oregon Progress Board, an independent state planning and oversight agency (2). Created by the Legislature in 1989, the Progress Board is responsible for implementing the state's 20-year strategic plan, Oregon Shines. The newest version of the strategic plan, Oregon Shines II, has three major goals: quality jobs for all Oregonians; safe, caring, and engaged communities; and, healthy sustainable surroundings (3).

Ten of the current Oregon benchmarks focus on traditional public health indicators, such as infant mortality, teen pregnancy, and percentage of adequately immunized two-year-olds. However, many of the other benchmarks have public health implications. The Progress Board realizes that connections exist between all three goals and most benchmarks.

Using a public process involving thousands of Oregon residents, the Oregon Progress Board established the juvenile (teen) arrest rate as one of the benchmarks for the goal of safe, caring, and engaged communities. The Clackamas County Public Health Division views the teen arrest rate as a benchmark with public health implications, and one where CHiME potentially can play an important role in the community partnership.

Even before being placed on the Web, the Clackamas County CHiME has involved community residents through a variety of venues, including the Reduce Adolescent Pregnancy Project (RAPP), the Healthy Communities Council, the Robert Wood Johnson Turning Point Partnership, and the Local Public Safety Coordinating Council. The local RAPP group is particularly interested in looking at teen birth rates by high school attendance area and by legislative district. Both groups are interested in looking at trend data.

Healthy Communities is a partnership involving community residents, local governments, hospitals, health plans, businesses, schools, religious leaders, and other agencies in the Portland metropolitan area. Clackamas County is working with the Healthy Communities Council to expand the number and variety of datasets available for the CHiME and, ultimately, to build an infrastructure for cooperation and data sharing across organizational boundaries.

Clackamas, Multnomah, and Washington Counties (the three counties in the Portland metropolitan area), in conjunction with the Healthy Communities Council, have developed a local partnership funded through the Robert Wood Johnson Turning Point Initiative to study how public health services are delivered and to make recommendations for improvements. One goal of our Turning Point initiative is to develop an integrated data system. Healthy Communities and Turning Point have expressed an interest in using the CHiME as a way of integrating and sharing data among all of our partners.

Before the development of the CHiME, Clackamas County law enforcement agencies used the location of crime and arrest events (rather than rates) in determining where to deploy resources. Following input from its Department of Human Services member, and in consideration of the established juvenile arrest rate benchmark, the Juvenile Crime Subcommittee of the Clackamas County Local Public Safety Coordinating Council became interested in looking at juvenile arrest rates as a measure of community health and safety. Their interest increased when they found that CHiME could allow them to map and analyze juvenile arrest rates and associated risk factors at the sub-county, community level. Because the Clackamas County Sheriff provides the raw reported crime data, the Clackamas County CHiME could help the Juvenile Crime

Subcommittee visualize patterns of juvenile arrests in relation to demographic factors, specific crimes committed, and community health indicators such as the poverty rate. An example of a geographic analysis of teen male arrest rates is illustrated in several sample maps (Figures 4–7). The case definition for a teen male arrest is the arrest of a male, age 10 to 17, that is reported by law enforcement agencies. Rates were calculated based on the residence of the arrested teen. Rates also may be calculated, however, based on location of the reported crime.

As illustrated in the sample maps, when calculating arrest rates for the community, county, and state, the CHiME provides 95% confidence intervals, making it possible for communities to determine whether their arrest rates are significantly above or below the benchmark arrest rates. By adding a time trend analysis feature, CHiME eventually will enable the Public Safety Coordinating Council and other community partners to evaluate the effectiveness of neighborhood level initiatives to prevent juvenile crime.

Discussion

We have learned several lessons from our early experience with the CHiME demonstration. We learned that communities can be defined in many ways and that polygon representations of rates are frequently more useful than point representation of events for community health assessment and community health planning efforts. We learned that the public must be involved early in the process in defining community and determining what issues are addressed in a community health assessment. High school attendance area proved useful as the unit of analysis because it was meaningful as a community definition for the general public and because for two of our measures (teen arrests and teen birth) it facilitated targeting interventions and educational messages at high school teachers, students, and their parents.

We have also learned that we need to be careful when making multiple statistical comparisons when, for example, we compare multiple community teen male arrest rates with the county rate. Consequently, the CHiME can calculate Bonferroni adjustments for these comparisons. Most importantly, we learned to be vigilant to ensure that cause-and-effect conclusions are not drawn from ecologic data. These data should raise questions, not answer them.

We are not alone in learning from our experience with the CHiME. Our governmental and private partners are learning that reported data must include an address field for the data to be useful in assessing community health. Of course, we have all learned that confidentiality safeguards are essential in analyzing data at the neighborhood level.

Several technological issues remain to be addressed, including the ability of our GIS system to match addresses accurately, especially in rural areas. Even in urban areas, new roads are often constructed or the names of existing roads are changed. Interestingly, during development of the CHiME, the address of the Clackamas County Health Clinic changed when the road name changed.

Future Plans

Even in the early stages of the CHiME application, we foresee future short-term and long-term developments. In the short term, within the current prototype application,

we envision adding additional datasets, both public and private, such as hospital discharge data. A time trend analysis will enable us to evaluate the effectiveness and outcomes of our health programs over time. The upcoming Web-based application will be more accessible than our current version. Shortly, we hope to replicate the current prototype application in other jurisdictions. The CHiME prototype application is universal; for replication elsewhere, all it requires are census block group data for the denominator, local county map data, and community definitions. The Data Wizard can easily be upgraded to allow incorporation of new county templates. Within the current prototype application, we plan to add documentation, including pop-up information screens, metadata, tutorials, help windows, hyperlinks to experts, and a report on the address match rate. We plan to add additional variables for stratification, such as income.

Within the short term, we envision coordination with other community health assessment initiatives such as APEXPH'98. Clackamas County is one of a few counties nationwide piloting the use of a draft version of APEXPH'98 software for the APEXPH Community Process (4). In many of these counties, a major issue has been how to assess community health, given the scattered locations of health-related data. APEXPH provides local communities with a tool to organize the process of community health assessment. For jurisdictions containing multiple or diverse communities, GIS tools such as CHiME can facilitate the APEXPH'98 process, both for the entire jurisdiction and at the sub-county, community level. APEXPH'98 and GIS tools are complimentary. Future versions of the APEXPH Community Process tool should include a geospatial component.

Within the long term, the next generation prototype CHiME application will allow users to define community while using the CHiME. Instead of conforming to pre-selected community boundaries like high school attendance areas, users will be able to draw their own community boundaries. The only restriction to community boundaries will be that they approximate census block group boundaries. The current prototype was developed with ArcView GIS, but future versions will be developed using application-independent languages such as Visual Basic, Java, and Map Objects.

Unfortunately, we also anticipate significant barriers to further development of our application. Upgrades will be expensive, and project needs are growing beyond the scope of Clackamas County. Perhaps this is our biggest lesson: the future of using GIS for community health improvement will require a committed, collaborative partnership of governmental and private agencies and consumers.

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